Author response to Ref2

General response

The comment correctly identifies the main contribution of the manuscript. The proposed framework is not intended to improve the intrinsic accuracy of the reconstructed velocity vectors, but rather to provide a spatial discretisation that is better adapted to the heterogeneous distribution of HF-radar observations. Its main benefits concern spatial representation, observational support, representativeness, and computational efficiency.

The proposed methodology therefore addresses a different problem from the reconstruction algorithm itself. Conventional regular grids impose a fixed spatial discretisation, irrespective of the local distribution and geometry of the available observations. In contrast, our framework uses constrained K-means clustering and Voronoi tessellation to distribute reconstruction nodes according to the local density and spatial organisation of the radar measurements.

This observation-driven discretisation affects how the available information is aggregated and represented in space. It leads to a more homogeneous observational support, improved node utilisation and radar–drifter spatial correspondence, while reducing the number of weakly constrained reconstruction nodes. These are the aspects that we consider the main scientific and practical contributions of the approach.

Increasing the resolution of a regular grid does not address the same issue. Although a finer regular grid can increase the density of reconstructed vectors, it still imposes a uniform discretisation and does not adapt the spatial distribution of nodes to the heterogeneous observational support. The adaptive framework instead allows the spatial resolution to follow the local information content of the observations.

Accordingly, the manuscript does not propose a new circulation product or a new inversion methodology. It introduces an observation-driven representation of HF-radar observations that can be used prior to reconstruction, analysis, assimilation, or comparison with numerical models.

Concerning the limited changes in RMSE and correlation

RMSE and correlation between the regular and adaptive grids are broadly similar. This result is fully consistent with the scope of the proposed methodology.

Both approaches use the same radial observations, quality-control procedures, reconstruction strategy, and validation dataset. The main sources of uncertainty associated with measurement noise, radar geometry, and angular conditioning are therefore essentially unchanged.

The purpose of the adaptive grid is instead to modify the spatial distribution and representativeness of the reconstructed field. In particular, the analysis of radar–drifter separation distances indicates that part of the scatter in radar–drifter comparisons is associated with spatial representativeness. By adapting the reconstruction nodes to the observational distribution, the adaptive grid reduces the mismatch between where the radar information is available and where the reconstructed vectors are located.

Thus, the similar RMSE and correlation values should be interpreted in the context of the specific quantity being evaluated: they indicate that the adaptive discretisation does not substantially change pointwise reconstruction accuracy, while other metrics related to spatial support and representativeness are affected.

Concerning the representation of mesoscale structures

The manuscript does not provide a dedicated quantitative metric to assess whether rotational structures, shear zones, or other mesoscale features are represented more accurately.

Our intention was not to claim the identification of new circulation structures or an improvement in their physical accuracy. Rather, the figures illustrate how the same information contained in the

radar observations is spatially represented when reconstruction nodes are adapted to the geometry and density of the available measurements.
The diagnostics presented in the manuscript therefore focus primarily on the discretisation itself, including node utilisation, spatial coverage, radial support, radar–drifter separation distances, and continuity of the reconstructed field.
Additional analyses based on virtual drifters, Lagrangian trajectory errors, separation statistics, or dispersion metrics could certainly provide further information on the impact of the adaptive discretisation on flow structures.

Concerning the need for regular grids in downstream applications

We agree that several oceanographic diagnostics, including divergence, vorticity, FSLE and some Lagrangian analyses, are more conveniently performed on a regular grid. Similarly, comparison with numerical model outputs may require the radar-derived velocity field to be transferred onto the model grid.
However, we do not consider this requirement to invalidate the use of an adaptive grid for the initial reconstruction. The two discretisations serve different purposes. The adaptive grid is designed to represent the spatial distribution of the observational information, whereas a regular grid may subsequently be used when required by a specific dynamical analysis or model application.
A relevant advantage of the adaptive approach is that it allows the spatial resolution of the reconstruction to follow the local observational support without imposing the highest resolution over the entire domain. For example, resolving coastal processes at scales of order 100 m with a conventional regular grid would require either a very fine resolution over the whole domain or the use of nested high-resolution domains. The latter introduces additional computational and methodological complexity, including the definition and management of interfaces between grids with different resolutions. It also requires the high-resolution regions to be defined a priori.
In contrast, the proposed approach determines the density of reconstruction nodes directly from the local distribution of the radar observations. High spatial resolution is therefore obtained where the observational support is sufficient, while a coarser representation is retained in regions where the available information is more limited. No a priori definition of nested domains or transition regions is required.
This distinction is particularly important for HF-radar observations, whose spatial sampling can be strongly heterogeneous and does not necessarily follow a simple nested-domain structure. The adaptive grid therefore provides an observation-driven representation of the velocity field before any subsequent interpolation, model comparison, or dynamical analysis.
We acknowledge that, for applications requiring a regular grid, the adaptive field may subsequently need to be interpolated onto that grid. This is a downstream requirement of the specific application and does not remove the advantage of performing the initial reconstruction on a discretisation adapted to the observational support. The benefit of the adaptive approach is that it avoids representing the observations at unnecessarily high resolution in poorly constrained regions while allowing a much finer spatial representation where the observations provide sufficient support.
We will clarify this distinction in the revised manuscript and emphasise that the adaptive grid is not intended to replace regular grids for all subsequent oceanographic applications, but to provide a more efficient and observation-consistent spatial representation of the HF-radar measurements.

Concerning advanced interpolation methods

We agree that the local interpolation used in the present study is relatively classical compared with approaches such as Optimal Mapping Analysis (OMA), 2DVAR, and other variational or non-local reconstruction methods. We will make this distinction more explicit in the revised manuscript.
Importantly, the adaptive discretisation is conceptually independent of the subsequent reconstruction or interpolation method. Its purpose is to define a spatial representation of the observations that reflects their local density and geometry. The same adaptive-grid construction could therefore be coupled with more advanced interpolation, inversion, uncertainty-weighted reconstruction, or data-assimilation schemes.
This separation between spatial discretisation and reconstruction methodology is also an intended feature of the framework, as it allows the proposed approach to be integrated with alternative reconstruction techniques without changing the grid-generation procedure.

Final remark

We appreciate the reviewer's comments, which helped us clarify the scope of the contribution. The manuscript addresses the spatial representation of heterogeneous HF-radar observations rather than seeking to improve pointwise reconstruction accuracy.
The main methodological contribution is the replacement of a fixed spatial discretisation with an information-adaptive one that reflects the geometry and density of the observations. The resulting benefits concern observational support, spatial representativeness, node utilisation, and computational efficiency. We believe that this framework can be useful for HF-radar applications in which these aspects are important, while recognising that it does not by itself constitute a new reconstruction algorithm or demonstrate improved pointwise accuracy.
We nevertheless consider the problem addressed in this manuscript to be relevant to Ocean Science because the spatial representativeness of observations directly affects the interpretation, validation, assimilation, and long-term exploitation of oceanographic measurements. The proposed framework therefore addresses not only a technical aspect of radar processing, but also a scientific problem related to how heterogeneous ocean observations are represented and used in oceanographic applications.
For this reason, we regard the proposed framework not merely as a technical development for HF-radar processing, but as a contribution to the broader problem of representing heterogeneous ocean observations in a manner that is consistent with their spatial information content. While the manuscript does not claim the discovery of new physical processes or circulation features, it addresses how heterogeneous ocean observations are represented and interpreted. Because observational representativeness influences the identification, validation, and analysis of coastal circulation patterns, we regard this issue as directly relevant to the study of coastal ocean dynamics rather than solely to instrumentation or data-processing technology.